The equivalents that have been deduced from only one compound, or of which the different determinations are not fairly accordant, are marked ? in the above Table.

The specific refractive energy of a body is in some respects worthy of more consideration than the refraction-equivalent, since, being only the refractive index minus 1 divided by the density, it is a physical property independent of chemical theories as to the atomic weight. Among suggestive facts are noticed the extreme energy of hydrogen; the existence of pairs of analogous elements having the same, or nearly the same, energy, —as bromine and iodine, arsenic and antimony, potassium and sodium, manganese and iron, nickel and cobalt; and that among the metals capable of forming soluble salts there is some connexion between their power to saturate the affinities of other elements, and their power to retard the rays of light.

XXV. "On the Structure of the Cerebral Hemispheres." By W. H. Broadbent, M.D., Lecturer on Physiology at St. Mary's Hospital Medical School, and Senior Assistant Physician to the Hospital, Physician to the Fever Hospital. Communicated by F. Sibson, M.D. Received June 17, 1869.

(Abstract.)

The object of the investigation has been twofold. First and chiefly, to endeavour to ascertain minutely the course of the fibres by which the convolutions of the hemisphere are connected with each other and with the crus and central ganglia.

Secondly, to endeavour to ascertain whether there is a constant similarity between the corresponding sides of different brains as compared with the opposite sides of the same brain; and should this be the case, to endeavour to trace the relation between any anatomical difference which might be discovered and such physiological difference as seems in the present state of our knowledge to be indicated by the association of loss of the faculty of language with disease of the *left* hemisphere rather than the right.

The present communication relates almost exclusively to the first branch of the investigation, and the method pursued has been to harden the brain by prolonged immersion in strong spirit, by which the fibres are rendered perfectly distinct and fairly tenacious, so that with care and patience their course and arrangement may be accurately ascertained.

Previous researches on the structure of the cerebrum have been mainly directed to the examination of the course and distribution of the fibres radiating from the crus and central ganglia, which have been assumed or supposed to occupy ultimately the axis of every convolution, the different convolutions being connected by fibres which crossed under the sulci from one to another. It is here shown that the commissural communication

between different parts of the hemisphere is much more extensive than has hitherto been described, and that the fibres more commonly run longitudinally in the convolutions than cross from one to another, while large tracts of convolutions have no direct connexion with the crus, central ganglia, or corpus callosum.

The preponderance of commissural over radiating fibres is indicated by a comparison of the sectional area of the latter as they issue from the central ganglia with the large surface of white matter displayed in the centrum ovale. The dissection by which this is shown in detail is begun on the under surface of the temporo- or occipito-sphenoidal lobe.

In this lobe the fibres are almost entirely longitudinal in their general direction. From near the apex fibres can be followed backwards in the two or three convolutions on the outer side of the gyrus uncinatus to near the centre of this surface of the lobe, where they end in the grey matter of a sort of lobule which I have ventured to call the collateral lobule. From the collateral lobule other fibres pass to the convolutions at the occipital extremity of the lobe, to convolutions on its outer side and to the calcarine end of the uncinate gyrus. These convolutions, comprising all those of the temporo-sphenoidal lobe except the gyrus uncinatus, the infra-marginal and parallel gyri, and the continuation of the two latter round the apex receive no fibres whatever from the crus, central ganglia or corpus callosum, but the ant. commissure spreads into them.

Beneath these is a beautiful plane of fibres which forms the floor of the descending cornu of the lateral ventricle, except at the anterior end; it forms the floor also of the ventricle at the entrance to the cornu, *i. e.* in the eminentia accessoria and of the posterior cornu; but here fibres of the C. callosum are mingled with those of the plane spoken of. This plane is formed as follows: along the axis of the lobe, in the hollow left by the removal of the superficial convolutions, runs a band of fibres from the apex to the posterior extremity; anteriorly this band contains numerous fibres, but in passing backwards they spread out towards the inner border of the lobe into a continuous lamina, which rests upon the lining membrane of the ventricle and its cornua. Some of the fibres run in the upper wall of the calcarine fissure to the postero-parietal lobule, others form a layer in the lower wall of this fissure, *i. e.* in the calcarine division of the gyrus uncinatus. The G. uncinatus remains as an elevation along the inner side of the shallow valley resulting from the dissection described, little encroached upon by it; its superficial fibres, however, must be removed to display the plane just mentioned. It incloses the cornu of the ventricle and the hippocampus, and is thus not a solid mass. Its fibres can be divided into two layers, a superficial set, the general direction of which is from the outer or collateral side anteriorly, backwards and inwards to the grey matter on its flat surface; and a deeper set, the fibres of which at the anterior part of the gyrus occupy its entire width, in passing backwards they converge, and near the inner border have a twisted arrangement, the inner fibres passing

beneath the outer to the grey matter of the hippocampus and to the splenium C. callosi, the outer fibres crossing over and reaching the upper wall of the calcarine fissure, in which they pass to the posteroparietal lobule and to the callosal gyrus.

The anterior enlarged extremity of the uncinate gyrus, sometimes called the uncinate lobule, is connected by bands of fibres with various parts; it is very firmly adherent to the subjacent structures, and when torn away leaves a patch of exposed grey matter, which has been named the internal grey nucleus. This is about in the same transverse line with the C. albicans, a little to the outer side of the optic tract.

By the removal of the uncinate lobule and gyrus fibres can be seen to pass from the apex of the lobe forwards in the fasciculus uncinatus, backwards and inwards along the roof of the cornu to the thalamus, and inwards to the grey nucleus.

On further dissection, which will consist in tracing the fibres from the apex backwards to various parts, and in removing little by little more of the convolutions along the outer edge of the lobe, and in a careful investigation of the parts about the calcarine fissure, the following appearances will be presented.

Along the axis of the lobe a longitudinal ridge with a slight convexity outwards, prominent posteriorly, subsiding anteriorly. On its inner side, from behind forwards, first the posterior cornu: next the outer wall of the ventricle, where the cornua enter it; this is formed by fibres curving directly backwards into the ridge from the thalamus (also from crus and corpus striatum, but more deeply), they are crossed transversely, however, by a thin lamina of fibres from the under surface of the splenium, which bend down from the roof of the ventricle and then curve forwards in the ridge: next the posterior end of the thalamus, which bends forwards round the crus, and gives off forwards from a pointed extremity the optic tract and laminæ of fibres on the outer side of this, which run above the roof of he cornu to the apex. Anteriorly this longitudinal ridge is continuous with the fasciculus uncinatus, and on its inner side are the internal grey nucleus, and more anteriorly the anterior perforated space between which the anterior commissure dips forwards and inwards in its canal.

On the outer side of the ridge fibres may be seen to start at the edge of the lobe, run inwards to the ridge, and curve forwards in it, to leave it again on its outer or inner side, or to pass with it to the fasciculus uncinatus.

A bundle of fibres taken up from the posterior part of the ridge would pass mainly to the thalamus; but some would proceed forwards in the ridge, and either turn outwards to some part of the inframarginal gyrus or apex, or inwards to the internal grey nucleus, or behind it. Others again go on in the F. uncinatus.

Fibres taken from the middle part of the ridge, and traced backwards, would mostly curve outwards to some part of the outer edge of the lobe,

but some would go to the tip; followed forwards, they spread out into a thin fan, and pass to the various points already indicated.

By repetition of this process the temporo-sphenoidal lobe will be exhausted, with the exception of a considerable lamina of fibres from the posterior part of the inframarginal gyrus, which passes backwards and inwards to the end of the fissure of Sylvius, round which it curves into the supramarginal gyrus, and another large band from the posterior end of the parallel gyrus, which curves upwards and turns forwards in the axis of the parietal lobe close behind the fibres which curve upwards from the corpus callosum to the margin of the longitudinal fissure.

It should be added that large bands of fibres run obliquely backwards in the parallel gyrus to the bottom of the sulcus of the same name, under which they turn to the inframarginal gyrus. When these are removed, the deep parallel sulcus is converted into a deep narrow valley.

The fasciculus uncinatus, in the dissection just described, has been seen to receive fibres from the occipital extremity of the hemisphere, and from various convolutions along its outer side, occipital, annectent, angular, parallel, and inframarginal; fibres are traceable into it also from the internal grey nucleus, these mostly lying beneath those from the convolutions, and it is probable that a few fibres from the thalamus and splenium find their way into it. As it emerges from under the temporo-sphenoidal lobe to cross the entrance to the fissure of Sylvius, it receives a considerable contribution from the overhanging apex of this lobe, and some from the uncinate lobule. Its general direction is forwards; but a superficial set of fibrse mainly from the apex of the temporo-sphenoidal lobe, passes inward as well as forwards, and spreads out mainly to the edge of the longitudinal fissure, passing under the olfactory sulcus; another lamina appears from beneath the edge of this, having a still more transverse direction, and its fibres go to the rostrum corporis callosi, and to the callosal gyrus, detaching the pointed origin of this convolution from the anterior perforated space. The fibres passing directly forwards spread out under the orbital convolutions to end in the grey matter around the edge of this lobule, some of the more superficial turning into one or two of the gyri at its posterior and outer margin. Deeper fibres run outwards as well as forwards, beneath the convolutions of the island of Reil to the posterior part of the inferior frontal gyrus; this is a tract of considerable size.

The convolutions of the orbitar lobule being entirely superficial to the radiating fibres of the fasciculus uncinatus, must be added to those on the under surface of the temporo-sphenoidal lobe as belonging to the class which have no direct central communications.

To this class also must be added, with a reservation to be noted presently, the gyri operti of the island. The summit and the anterior convolutions rest upon the part of the F. uncinatus which passes to the outer corner of the orbitar lobule and the third frontal gyrus, and the fibres arising in the grey matter of this portion of the island curve forwards across the fissure to

the same convolutions; the corner of the orbital lobule in fact is carried away entirely by the fibres from the fasciculus and island. In the same way fibres starting in the remaining convolutions of the island cross the fissure and turn up in the supramarginal gyrus, leaving the outer surface of the C. striatum perfectly smooth, and converting the Sylvian fissure into a deep wide valley. The wall of the C. striatum thus exposed consists of a lamina of fibres, which radiate in all directions from a small patch of grey matter laid bare at the middle and highest point of the eminence this ganglion forms as seen from this aspect; and it is possible that there may be here some sort of continuity or connexion between the grey matter of the C. striatum and the overlying part of the convolutions of the island. Except at this point, the convolutions are separated from the C. striatum by a very distinct plane of fibres.

The gyri operti are thus connected mainly with the supramarginal gyrus and its continuation along the anterior wall of the fissure. Some fibres, however, pass from the grey matter of the overhanging inframarginal gyrus near the apex into the corresponding part of the island, and about the grey nucleus exposed at the summit of the C. striatum deep fibres from the posterior extremity of the hemisphere and from the F. uncinatus seem to join both the nucleus and the overlying grey matter of the island.

The temporo-sphenoidal lobe having been gradually removed, and with it a great part of the occipital lobe, a stage of the dissection is reached at which the distribution of the fibres of the splenium C. callosi and the relations of the crus and central ganglia, as seen from the under aspect, may be conveniently described.

On the inferior surface of the posterior extremity of the C. callosum is seen a transverse flattened elevation, which may be compared to the rostrum at the anterior extremity on a smaller scale and adherent to the body of the great commissure. It would thus be looked upon as a recurved part of the C. callosum. In the middle line it is adherent, but the fibres it sends transversely outwards leave the C. callosum proper, and bend downwards so as to cross the floor of the ventricle instead of the roof; they pass to the hippocampus major and minor, which they contribute to form, and run across the eminentia accessoria, and along the floor of the posterior cornu.

The hippocampus minor is formed by the projection into the posterior cornu of the bottom of the calcarine fissure; but an incision through the bottom of the fissure into the cornu would not split up the hippocampus, but would leave it attached entire to the upper wall of the cornu. The fibres from the splenium, which contribute to the formation of the hippocampus minor, run longitudinally along it immediately beneath the lining membrane of the ventricle, and when reached by dissection from without present a delicate lamina in the form of a groove between two curved tracts passing backwards to the posterior extremity of the hemisphere, the upper from the C. callosum proper, the lower from its recurved process.

The hippocampus major may be briefly described as a curved groove or "gutter" (Gratiolet) of fibres, the upper border of which is formed by the posterior pillar of the fornix, while the lower is concealed by the gyrus uncinatus, the grey matter of which folds over it into the groove, and after reaching the bottom bends up the other wall for a short distance, forming the plicated "C. fimbriatum," or "Pli godronné." The outer surface of the case of fibres is smooth, and for the most part free in the descending cornu; it adheres to the inferior wall formed by the plane of fibres previously described, but can easily be detached. The course of the fibres forming the case or groove is from the lower edge backwards and upwards round the convexity to the upper edge, where they pass into the pillar of the fornix, or where the hippocampus joins the splenium, into the recurved process. Further details are given in the paper itself.

The fibres crossing the floor of the ventricle curve forward, apparently towards the apex, but are too few to be followed absolutely to their termination.

From the body of the C. callosum, at its posterior part, the fibres mostly radiate backwards and outwards into the cuneus and occipital lobe generally; but a considerable number on the under surface bend from the roof of the ventricle down its outer wall, across the longitudinal fibres from the thalamus, &c., and curve forwards in the ridge. A considerable proportion of these has been traced to the internal grey nucleus, others seem to pass forwards to the grey matter near the apex of the temporo-sphenoidal lobe.

The relations of the crus and great central ganglia may be described as follows. The crus, as it plunges into the hemisphere, is encircled on its inferior aspect by the optic tract; it then expands into a large fan of fibres, the edges of which are antero-posterior, the surfaces obliquely upwards and inwards, and downwards and outwards. The two great ganglia, the C. striatum and thalamus may be said to sit astride the anterior and posterior edge respectively of the fan, each having an intra- and extraventricular part, the C. striatum being much the larger, and situate above, as well as in front of the thalamus.

When the optic tract is removed, the groove in which it rests is seen to present fibres having the same general direction round the crus; they have been called by Gratiolet "l'anse du pédoncle," a term which may be translated by the expression "the collar of the crus." The most conspicuous part of the collar consists of fibres from the thalamus, which curve forward round the crus to end in the tuber cinereum, or run up in the wall of the third ventricle to the velum interpositum, &c. Within this fibres are seen to turn forwards from the posterior border of both crust and tegment of the crus, to end in the C. striatum, and anteriorly a considerable mass of fibres from the tegmentum curves with a bold sweep round the edge of the crust, and passes backwards and outwards into this same ganglion.

The extra-ventricular part of the thalamus is seen in the descending cornu curving round the crus. From its anterior pointed extremity it is continued onwards by the optic tract, and it sends fibres,—1. Forwards in the collar of the crus. 2. Forwards and outwards to the convolutions about the apex in a succession of laminæ, the deeper fibres passing more outwards than the superficial sets, and emerging from under them along the outer edge of the roof of the cornu. 3. From under the fibres which pass forwards, it sends backwards a large mass along the outer wall of the ventricle and posterior cornu to the occipital end of the hemisphere.

The extraventricular corpus striatum has been exposed on two sides; it forms a very large mass, and has a large rounded anterior end, while posteriorly it narrows to a tail-like extremity. The outer aspect forms an elongated eminence, rising out of the Sylvian valley, highest at the centre, subsiding towards each end; at the summit is the external grey nucleus, from which radiate fibres forwards, backwards, and outwards. Those passing forwards form a large bundle; they spread out into a fan, and proceed mainly to the third frontal convolution; those passing backwards accompany the fibres from the thalamus to the occipital extremity of the hemisphere; those passing outwards with varying degrees of obliquity descend the wall of the ganglion to the Sylvian valley; but instead of crossing it to the convolutions on the other side, as might be expected from the apparent continuity of the walls and floor, dip between the fibres of the floor, which are the radiating fibres of the crus issuing from the C. striatum, and pass to convolutions in the frontal lobe. A remarkable fact respecting the planes of radiating fibres which form the limiting wall of the C. striatum on this aspect is, that the fibres all seem to have their origin in the small patch of grey matter here called the external grey nucleus, and they come off clean from the mass of soft grey matter forming the body of the ganglion.

On the under surface of the C. striatum, which is flat, are seen the internal grey nucleus and the anterior perforated space, between which the anterior commissure passes outwards and backwards from the ventricle in a distinct canal to emerge on this surface. The external grey nucleus also appears in the outer border, and is about in the same transverse line as the C. albicans and internal grey nucleus, from which last it is only separated by a narrow band of longitudinal fibres. Here again the planes of fibres, which form the limiting wall of the ganglion, end in the grey nuclei, and seem to have no communication with the mass of soft grey matter they inclose.

The anterior edge of the fan-like expansion of the crus emerges from the large end of the C. striatum, and, properly speaking, divides the intra-ventricular C. striatum from the extra-ventricular division; the anterior perforated space, being on the inner side of the radiating fibres, belongs to the former.

Before the dissection of the fronto-parietal portion of the hemisphere is

described, a brief account is given of the intraventricular thalamus and C. striatum.

When the tænia semicircularis is removed, and the edge of the C. striatum pushed back, large rounded cords of fibres are seen radiating outwards in all directions from the thalamus with the fibres of the crus, posteriorly slender flat bands of fibres curve backwards from the narrowing extremity of the C. striatum to dip down between them (together with fibres apparently belonging to the tænia) ; they can be traced through the fan of radiating fibres to the extraventricular C. striatum. Anteriorly the soft grey matter of the C. striatum fills the spaces between the diverging cords ; but no distinct origin of fibres in the mass of grey matter is here met with.

The plan of construction of the frontoparietal portion of the hemisphere seems to be as follows :—

The C. callosum divides into two main planes of fibres, one of which turns up to the margin of the great longitudinal fissure, the other passes onward to the supramarginal gyrus of the fissure of Sylvius. The radiating central fibres approach the under surface of these at the acute angle, and pass obliquely between them before the ascending and descending planes have well separated from each other, the central as well as the callosal fibres going mainly to the margins of the hemisphere. An angle is thus left along the axis of the frontal and parietal lobes, which is occupied by a vast longitudinal system of fibres, some of which have already been mentioned as entering this part of the hemisphere from the temporo-sphenoidal lobe. Large bands turn upwards and then forwards from the parallel and angular gyri, that from the parallel gyrus running forward close behind the ascending callosal lamina; other fibres turn forwards from the annectent gyri, and more anteriorly from the posteroparietal lobule; still further forwards some of these fibres coming from behind bend upwards, and end in the parietal convolutions ; while others start in the same gyri, and pass forwards, the principle of construction being apparently simple, but the details extremely intricate. At the decussation the central and callosal fibres are worn into a compact inextricable mass, and the difficulty of following the different sets is increased by the fact that the central fibres are not transverse in direction like those of the C. callosum, but mostly very oblique backwards or forwards, as may best be seen by examining the bands radiating under the C. striatum from the thalamus ; this necessitates corresponding obliquity in the fissures through which the central fibres penetrate the C. callosum. A few fibres from the under surface of the C. callosum turn inwards to the centres ; but the statement of Gratiolet that all the fibres of this commissure can be traced from the central radiations on one side to the convolutions on the other, is not confirmed.

The detailed dissection of the parieto-frontal convolutions need not be given here. It will be sufficient to mention that the posteroparietal and

supramarginal lobules are connected by numerous bands of fibres, that the ascending parietal gyri have central and callosal fibres entering their extremities, the middle portion receiving comparatively few; the first, however, sometimes called the ascending frontal gyrus, seems to have numerous fibres from the centres and C. callosum along its entire length. The second frontal convolution sends bands of fibres obliquely to the two others, and has fewer radiating fibres than they have. When it is removed, fibres can be traced transversely across the valley left from the first to the third.

A few additional particulars are given respecting the arrangement and course of the fibres in the callosal and marginal gyri on the internal surface of the hemisphere, and the contrast between the thalamus and C. striatum as to structure and relations is pointed out, the thalamus sending large masses of fibres in every direction, chiefly with the radiating crus, the corpus striatum consisting of soft grey matter enclosed in fibrous planes which arise in the comparatively small grey nuclei, and have apparently no communication with the main body of the ganglion. The thalamus again does not seem to receive terminating ascending fibres, while both divisions of the crus give off numerous fibres, which are seen to end in the C. striatum.

The differences in naked-eye appearances indicate differences in the relations between cells and fibres in the two ganglia, the exact nature of which can be ascertained only by the microscope.

XXVI. "On the Rhizopodal Fauna of the Deep Sea." By William B. Carpenter, M.D., V.P.R.S. Received June 17, 1869.

(Abstract.)

The Author commences by referring to the knowledge of the Rhizopodal Fauna of the Deep Sea which has been gradually acquired by the examination of specimens of the bottom brought up by the Sounding-apparatus; and states that whilst this method of investigation has made known the vast extent and diffusion of Foraminiferal life at great depths,—especially in the case of *Globigerina-mud*, which has been proved to cover a large part of the bottom of the North Atlantic Ocean,—it has not added any new Generic types to those discoverable in comparatively shallow waters. With the exception of a few forms, which, like *Globigerina*, find their most congenial home, and attain their greatest development, at great depths, the general rule has seemed to be that *Foraminifera* are progressively dwarfed in proportion to increase of depth, as they are by a change from a warmer to a colder climate; those which are brought up from great depths in the Equatorial region bearing a much stronger resemblance to those of the colder-temperate, or even of the Arctic seas, than to the littoral forms of their own region.

The Author then refers to the recent researches of Prof. Huxley upon